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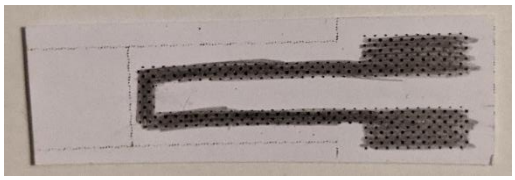
Low power flex sensor based on graphite granular system

General features

- Flex sensor
- Low power consumption
- Easy to use
- Thin
- Low-cost
- Portable
- Environment friendly



Description

This flex sensor is made from basic paper and graphite dropped by a pencil. By drawing with a pencil on a sheet of paper we rub off graphite particles which then stick to the paper fibers. Those particles form granular system. When the sensor is compressed the grains of graphite get closer to each other and thus quantum tunneling allow more electrons to travel from a grain to another. The overall electrical resistance of the sensor lowers when compressed and heightens when expanded. This sensor can be used as a flex sensor compressing and expending according to the direction of the flexion. It is a passive sensor; we only need to measure its electrical resistance. The relative resistance is around a few MΩ with an HB pencil, it therefore does not consume much power. It is low-cost and easy to make. It is thin and with the good integration can be easy to transport. Like paper and pencil, it is environment friendly.

Specifications

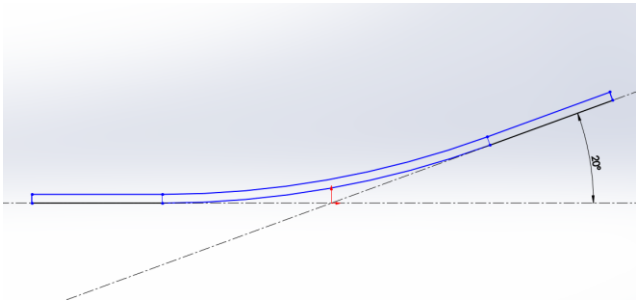
Type	Flex sensor
Sensing principle	Granular system sensor
Materials	Paper and graphite from pencil
Power supply requirement	Passive (no power supply required)
Nature of output signal	Analog resistivity
Dimensions	15mm x 37mm
Mounting	Glue or tape

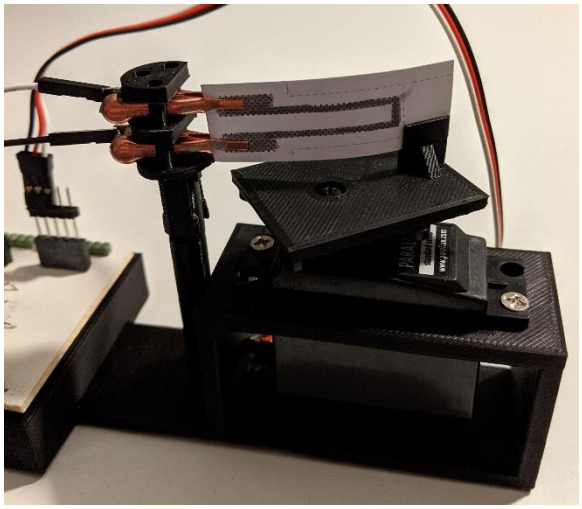
Standard use condition

	Unit	Typical value
Temperature	°C	20±5
Humidity	%	60±5
Air quality	%N2/O2	80/20

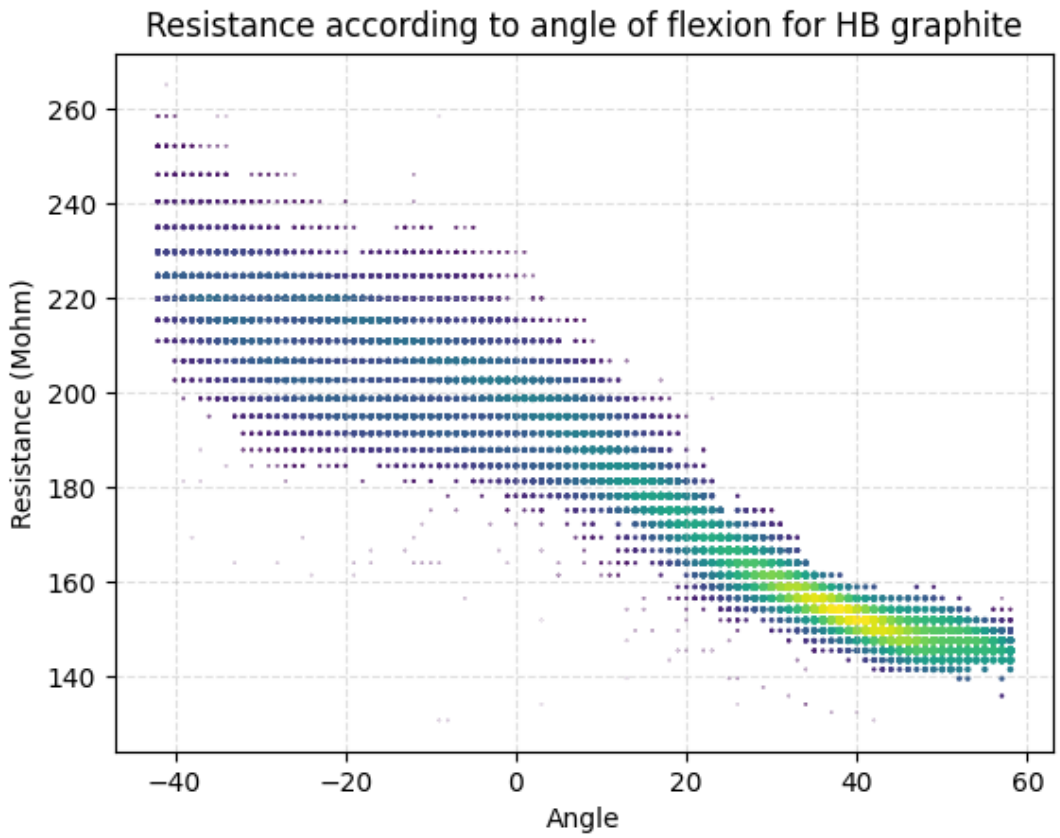
Flex Characteristics

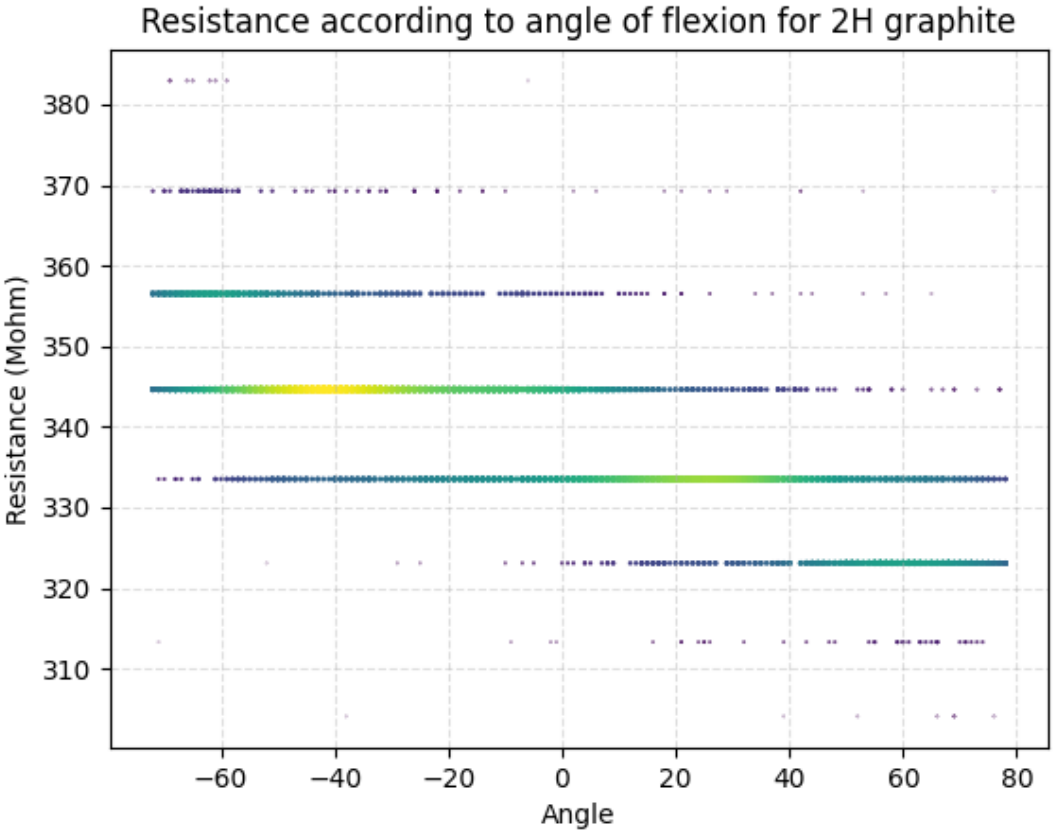
The characteristics of the sensor were determined by measuring its resistance when bent by a servomotor. The measured values are according to the angle of bending as shown in the figure below.

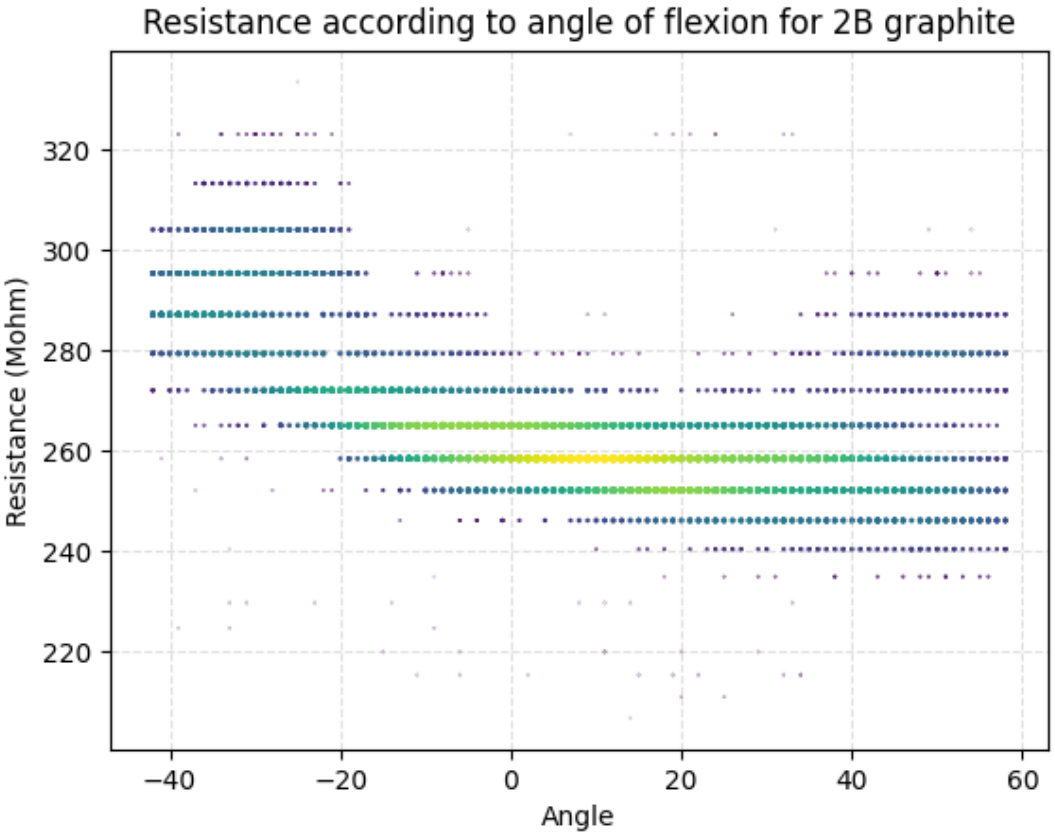




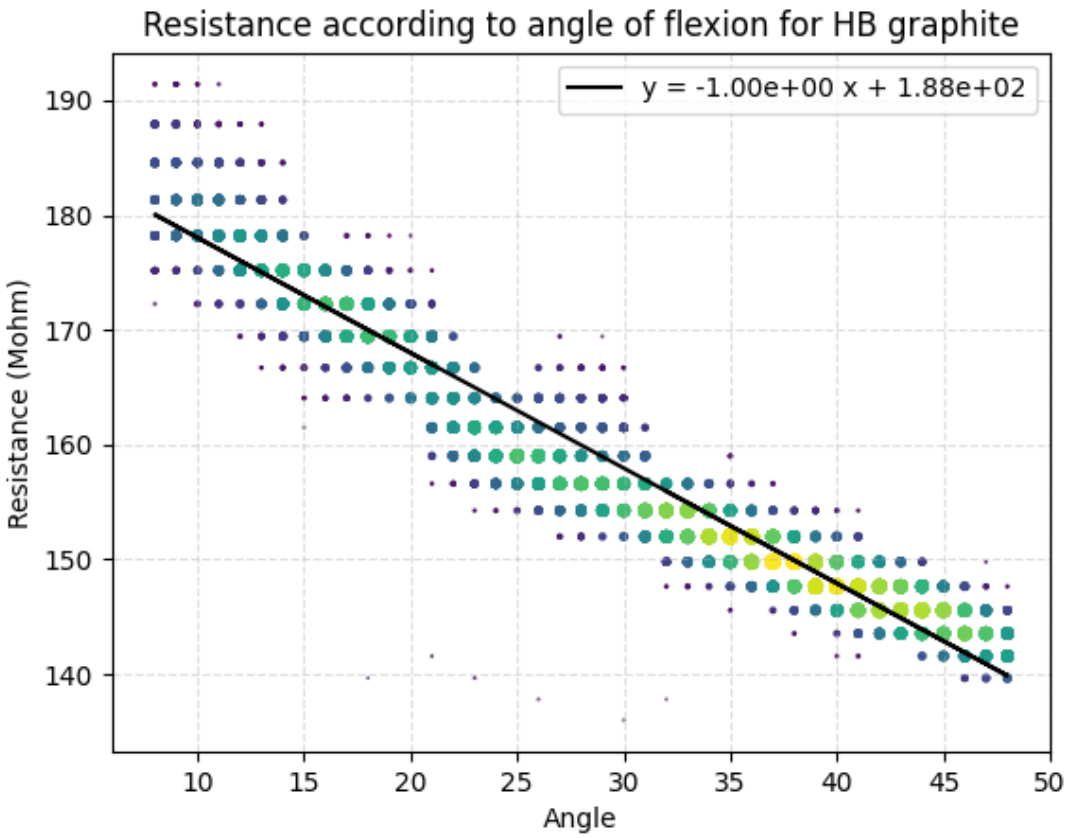
By testing multiple times multiple angles at different moments, we get an overview of the analog response of the sensor to different flexion.

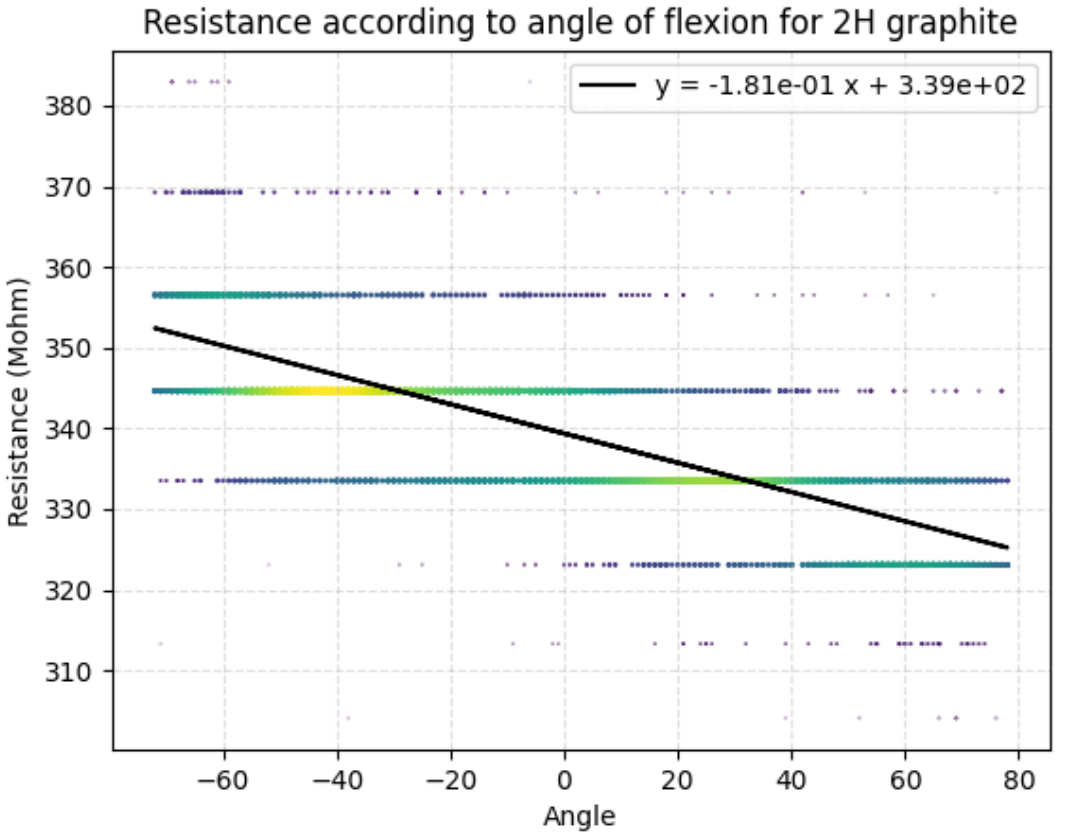


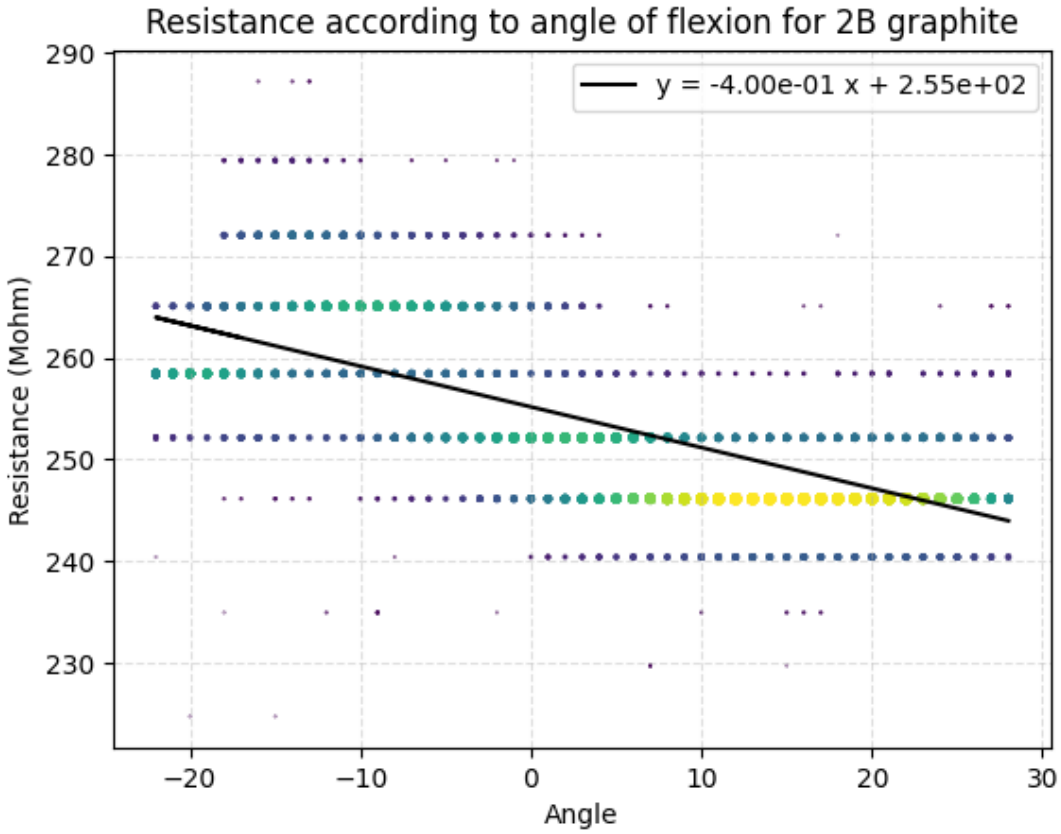

Resistance according to angle of flexion for 2H graphite
Resistance (Mohm)
380
370
360
350
340
330
320
310
−60
−40
−20
0
20
40
60
80
Angle


Resistance according to angle of flexion for 2B graphite
Resistance (Mohm)
320
300
280
260
240
220
−40
−20
0
20
40
60
Angle

We highly recommend the use of only the linear part of the previous curves with a high density of points.







Type of pencil	Average resistance*	Min-Max resistance*	Sensitivity	Correlation score (R^2)
HB	160 MΩ	130-200 MΩ	1000 kΩ/°	0.90
2H	340 MΩ	310-370 MΩ	181 kΩ/°	0.41
2B	250 MΩ	230-280 MΩ	400 kΩ/°	0.39

*in linear part

Example of integration

Below is an example of an integration circuit used to interface the flex sensor with an Arduino analog input pin. The operational amplifier will convert and amplify a current proportionally to the resistance of the flex sensor.